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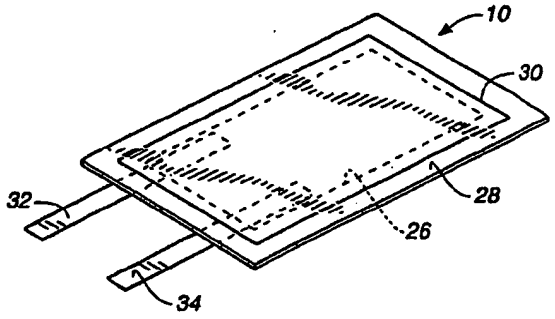
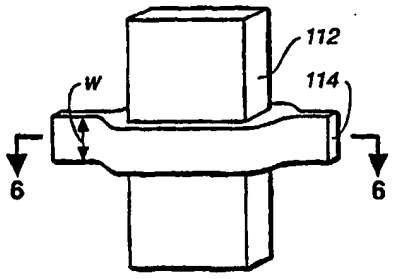
(54) Title: SEALABLE BATTERY TAB AND METHOD OF MAKING ELECTRICAL BATTERY WITH SEALABLE BATTERY TAB

(57) Abstract

A technique that seals a thick battery tab (32, 34) to the protective package (28) enclosing an electrical battery cell (26) using the heat sealable material (114). A middle portion of an elongated tab (32, 34) having an uneven surface is coated with the heat sealable material (114) forming a strip of such material. The strip of heat-sealable material is sealed to the protective package (28) by heating and applying pressure to the heat-sealable material (114) and the protective package (28). The tab (32, 34) may be solid material with a patterned or randomly uneven surface, a mesh of metal, or an expanded metal.





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SEALABLE BATTERY TAB AND METHOD OF MAKING ELECTRICAL BATTERY WITH SEALABLE BATTERY TAB

Background of the Invention

This invention relates to a battery using a sealable battery tab and method for making such a battery.

A conventional single electrical cell typically includes an anode, a layer of an ionically conductive electrolyte that contacts the anode, and a cathode layer that contacts the side of the electrolyte which is not in contact with the anode layer. A cathode tab is electrically connected to the cathode and an anode tab is electrically connected to the anode. These tabs form the anode and cathode terminals of the battery.

Conventional battery cells such as described above are typically covered with a protective package layer that prevents moisture and/or air from entering the cell inner space. This is desirable since moisture and/or air may cause different chemical reactions with the electrolyte, anode or cathode layers and may destroy a multicell battery or shorten its lifetime.

Conventional thin copper tabs that are used to form the battery terminals can be relatively easily sealed in the protective package where the thickness of the thin tabs is in the range of 1-2 mils. However, thin copper tabs are not as good in terms of mechanical strength as thick copper tabs and are not very durable. Therefore, a first objective of the present invention is to create a cell with a tab that has the same or equivalent sealability of a thin copper tab and the

durability of a thicker tab.

Electrical batteries such as those described above are used in low-power and high-power applications. An example of a low-power application is a battery for a portable telephone. The amplitude of electrical current required in a portable telephone battery is relatively small. However, the thin copper tabs used in such a battery have relatively high electrical resistance when compared with thicker copper tabs. Because of the relatively high resistance inherent in thin copper tabs, even a small amount of electrical current passing through such a tab may be enough to heat up the thin copper tab and to cause the melting of the package material that covers each cell. Indeed, the package material usually comprises plastic and aluminum foil and can in fact be ignited under certain circumstances. Therefore, it is desirable to decrease the resistance of the tab of the battery in order to decrease the temperature of the tabs during use and to reduce the probability of melting or ignition of the cell package. Accordingly, a thicker tab that has lower electrical resistance than a thin copper tab is preferable to increase the safety of the multicell battery. However, it is difficult to connect a thick copper tab to the protective package in a manner to provide hermetic sealing of the package. The second objective of the present invention is to provide an electrical cell with a thick tab that can be hermetically sealed to the protective package covering the cell.

An example of a high-power application of the multicell electrical battery is an SLI (starting, lighting and ignition) battery that is used for starting, lighting, or igniting an engine of a motor vehicle. In order to start, light or ignite an engine, the impulse of electrical current supplied by a SLI battery normally should have a high amplitude and therefore

requires the SLI battery to have a large amount of electrical capacity. Accordingly, it is necessary to lower the impedance of each element of the battery in order to minimize the energy losses inside the battery and to make the battery more efficient. Additionally, since a high power electrical battery is required to deliver high amplitude current, a tab with a relatively high electrical resistance will cause undesirable heating of the tab to high temperatures. It is therefore desirable to employ tabs with low electrical resistance to reduce the probability of melting and ignition of the protective package. An example of a tab with low resistance in an SLI battery is a thicker tab made of a solid material, such as copper metal. However, it is difficult to hermetically seal a thick tab to the package material. As a result, hermeticity, safety, and energy efficiency of the conventional electrical battery cannot be simultaneously achieved in a conventional design. Therefore, an additional objective of the present invention is to provide a tab having the electrical properties of a thicker tab and the same or equivalent sealability of a thin tab, and therefore a tab that can be used in a SLI battery.

Summary of the Invention

One aspect of the present invention is directed to an electrical battery comprising at least one electrical cell. The electrical cell includes at least one terminal with a portion having an uneven surface with protrusions and/or depressions of at least about 10 microns in height from a reference plane. The electrical cell is enclosed by a protective package layer that is sealingly connected to the terminal along the portion having the uneven surface to achieve a better seal. In the preferred embodiment the protrusions or depressions can be made in a repeated pattern or can be random, or

the protrusions or depressions can be formed by using a mesh or expanded metal material for the terminal.

Another aspect of the present invention is directed to an electrical battery comprising at least one electrical cell, said cell including at least one terminal and a protective package layer surrounding said at least one cell, said layer sealingly connected to said terminal, said terminal having a thickness greater than 2 mils and said protective package layer having a thickness of 7 mils or less. The terminal can comprise a mesh structure, an expanded metal, or a solid metal with an uneven surface.

One more aspect of the present invention is directed to an electrical battery comprising a layer of sealable material sealingly connected between the portion of the terminal and the protective layer, wherein the sealable material is different from but compatible with material of the protective package layer. In the preferred embodiment, the sealable material layer is in the shape of an elongated strip having a cross-section with gradual curvature.

Yet another aspect of the present invention is directed to a method of making an electrical battery comprising the following steps: (a) coating or impregnating at least a portion of a terminal with a sealable material; (b) enclosing an electrical cell with a protective layer; and (c) sealing the sealable material on or in the terminal to said protective layer.

In one embodiment the terminal comprises a mesh structure or an expanded metal. Then the step of coating or impregnating the portion of the terminal with the sealable material may include impregnating the terminal with the sealable material. The impregnating step may include dipping the terminal into a solution of plastic. Instead of impregnating a terminal, the step of coating or impregnating the portion of the terminal

with a sealable material may include molding the sealable material around the terminal.

After the terminal is coated either by impregnating or by molding, the step of sealing preferably includes the steps of heating and applying pressure to the portion of the terminal and the layer of sealable material, and to the protective layer.

Brief Description of the Drawings

FIG. 1 is a perspective view of a battery assembly showing a laminar thin cell battery in phantom enveloped by a heat-sealed moisture impermeable multilayered sheet material useful for illustrating the instant invention.

FIG. 2 is an exploded perspective view of the laminar thin cell battery of FIG. 1.

FIG. 3A is a perspective view of a solid thick metal tab that is surrounded by a strip of a sealable material to illustrate an embodiment of the invention.

FIG. 3B shows a perspective view of a metal mesh tab coated by a seal strip to illustrate another embodiment of the invention.

FIG. 3C illustrates a process of molding for making the seal strips of Figs. 3A, 3B.

FIG. 4A illustrates a process of sealing a terminal with a strip of a sealable material to a protective package to illustrate the invention.

FIG. 4B illustrates a metal mesh tab being impregnated by a sealable material to illustrate still another embodiment of the invention.

FIG. 5A depicts a top view of a portion of a solid tab that has an uneven rough surface to illustrate yet another embodiment of the invention.

FIG. 5B illustrates a cross-sectional view of a portion of the tab of FIG. 5A along the line 5B-5B in FIG. 5A.

FIG. 6 depicts a cross-sectional view of a portion of a solid tab with a rough surface sealingly connected to a strip of the heat-sealable material with a gradual curvature taken along the line 6-6 in FIG. 3A.

Identical components in the different figures are labeled by the same numerals.

Detailed Description of the Preferred Embodiment

As used herein, the term "battery" may include a single cell, or a plurality of cells, connected in either series or parallel fashion to furnish electrical current. As illustrated in FIG. 1, a battery assembly 10 including a thin cell laminar battery 26, shown in phantom, is enveloped by a protective package layer (or multilayer) 28 impermeable to air and water. The package layer is heat-sealed around periphery 30 of the cell. The protective package layer or multilayer typically comprises one or more plastic material layers and an aluminum foil.

Referring to FIG. 2, the battery 26 of FIG. 1 is a cell laminate which includes an anode layer 12, first and second layers of an ionically conductive electrolyte 14, 16 which contact anode 12 on opposite sides respectively, first and second cathode layers 18, 20 which contact the sides of electrolyte 14 and 16 which are not in contact with anode layer 12. Current collectors 22 and 24 contact the sides of cathode layers 18 and 20 which are not in contact with electrolyte layers 14 and 16. The cell depicted in FIG. 2 is a bi-faced structure to maximize the use of anode 12. The bi-faced, bi-polar, or other cell configuration designs are known to those skilled in the art. As shown in FIG. 1, an anode tab (or terminal) 32 is electrically connected to an anode 12. A cathode tab (or terminal) 34 is electrically connected to cathodes 18 and 20.

The invention is based on the observation that, where a thicker tab is used, the thicker tab can be sealed to the package by a number of means, even though the package layer is not thicker than the tab. In one embodiment, the tab has a portion with an uneven surface with protrusions or depressions of more than 10 microns in height from a reference surface plane representing the surface of the portion. Such uneven surface enhances the sealability of the tab to the package material, or an intermediate layer between the tab and the package. A battery tab, such as tabs 32, 34, can comprise a solid metal, for instance copper. In such event, the uneven surface can be achieved by imprinting a random or repeated pattern of depressions on a portion of the tab. Alternatively, a battery tab can comprise a mesh of metal, where the uneven surface is inherent in the structure of the mesh. The mesh of metal is a woven fabric comprising metal strands. There are several commercially available brands of metal mesh. For instance, Monsanto Corporation, St. Louis, MO manufactures a material sold under the name Flectron®, comprising a woven fabric made of metal coated nylon fibers. A battery tab can also comprise an expanded metal. The expanded metal comprises a grid of metal wires. There are several commercially available brand names of expanded metal. For instance, the Spantek Corporation, Hopkins, MN, produces the material Blanks-to Size™. The Delker Corporation, Branford, CT, manufactures the material sold under the name MicroGrid™ and Buffalo Wire Works Corporation, Buffalo, NY produces the material sold under the name Buffaloy®.

If a thickness of a tab is small compared to the thickness of the protective package layer, the tab can be easily sealed to the protective package layer by heating. Heating makes the package plastic material hot and fluid. If the package material is thicker than the

tab, there is enough material in the protective package to hermetically seal the anode and cathode tabs. In such a situation, the liquefied plastic will flow around the tabs making a good seal. In the preferred embodiment a typical thickness of a protective package material is 7 mils or less. While using a protective layer thicker than 7 mils is possible, this is undesirable because more material is required and because this increases the overall thickness of the resulting packaged cell.

If the thickness of a tab is significantly less than the 7 mil thickness of the protective layer, such as where the tab is about 2 mils thick, the tab can be easily sealed to the protective package. However, a tab with a thickness of about 2 mils has a relatively high electrical resistance. The high electrical resistance of the battery tab makes the battery less energy efficient because of energy loss due to high tab impedance. To be efficient, a commercial battery preferably has a "thick" tab with the thickness within the range of (13-15) mils. Such a thick tab is difficult to seal with the protective package material of typical thickness using conventional techniques. This problem is solved by the present invention, which discloses several techniques for sealing a thick tab to a protective package.

In lieu of or in addition to employing a tab with an uneven surface, sealability can be achieved or further enhanced by forming a strip of sealable material around a portion of the tab. Fig. 3A depicts a solid thick metal tab 112 a portion of which is covered by a strip of a sealable material 114. The width w of the strip is preferably about 125 mils and the strip preferably has a thickness of about 1-5 mils. The strip of the sealable material 114 is first connected and sealed to the thick solid metal tab 112; the strip is

then connected to the protective package material to form a hermetic seal of the tab and of the electrical cell. Using the above-described technique, a tab with thickness of greater than about 2 mils can be hermetically sealed to he protective package material having a thickness of 7 mils or less. A strip 114 can also be formed and sealed to a tab 112' made of a mesh as shown in Fig. 3B, or made of an expanded metal. As used in this application the portion of the sealable material 114 being used to cover a portion of the metal tab 112 is referred to as "coating", irrespective of whether the tab is made of a solid, mesh or expanded metal type material.

The formation of the strip is illustrated in Fig. 3C. As shown in Fig. 3C, tab 112 is sandwiched between two mold pieces 116 that define cavity 114' between the pieces and tab 112, where cavity 114' has the shape of strip 114 in Fig. 3A. A liquid sealable material such as a resin is injected or otherwise transferred to mold cavity 114', to form the strip 114. Fig. 3C shows a cross-sectional view of tab 112 and of cavity 114' and mold pieces 116. The strip 114 around mesh tab 112' can be formed using a process similar to that described above. The detailed molding process is known to those skilled in the art and will not be elaborated herein.

After the strip of the sealable material 114 is formed, it is then connected and sealed to the protective package material 138 as shown in FIG. 4A. As shown in Fig. 4A, end 112a of the tab 112 and the strip 114 are inserted into an envelope 28 with strip 114 aligned with one edge 28a of the envelope. Heat and/or pressure is then applied towards the strip and edge 28a along directions of arrows 140 perpendicular to the plane of Fig. 4A to sealingly connect the strip to the envelope 28 material, thereby hermetically sealing cell 26 from

the environment. The sealable material in strip 114 does not have to be the same as the package material. However, the sealable material has to be "compatible" with the package material in order for hermetic sealing to occur between them. The "compatibility" of the strip of the sealable material with the protective package material is defined as a high probability that the sealable material will sealingly attach to the protective package material to achieve hermetically sealed packages.

When the material in strip 114 is heat-sealable, it can coat the thick tab 112 and be sealed to the protective package by application of heat. There are several commercially available materials that can be used for this purpose for strip 114. For instance, polyethylene, Dow Primacor®, Du Pont Surlyn®, and ethylene acrylic acetate (EAA) are examples of heat-sealable materials. The process of coating a thick metal tab with a strip of the heat sealable material is described further below. Also, described further below is the process of sealing the strip of the heat sealable material to a protective package itself.

A second technique for coating a thick mesh tab or a thick expanded metal tab 150 with a sealable material to form an impregnated portion 153 is shown in FIG. 4B. This is an "impregnating" approach.

The impregnating process can be performed in one of several ways. The first technique is dipping a center portion of the mesh or expanded metal tab into a solution of liquid plastic. This may be performed by immersing a center portion in the solution of liquid plastic to form the impregnated portion 153. Alternatively, a solution of liquid plastic or thermoplastic resin may be injected into a middle or center portion of the mesh tab or expanded metal tab to form the portion 153. Yet a second alternative is by placing a center

portion of the tab into a die with cavity and filling the cavity with the solution of liquid plastic in a manner similar to that described above in reference to Fig. 3C for coating a solid metal tab. Such molding process would expose the center portion of the mesh or expanded metal tab to the liquid plastic in the cavity of the die. After the plastic solidifies in the mesh or expanded metal to form portion 153, the tab is removed from the die together with the plastic.

The injection of the plastic or thermoplastic into mesh or expanded metal tab can be also done by a "press and heat" combination. The "press and heat" combination means covering a center portion of the tab with the plastic material and placing them under pressure in the range of 500-2500 psi and heating them in the range of 250^{0}F-300°F. This would cause the melting of the plastic material and lamination of the center portion of the mesh or expanded metal tab and the liquid plastic material to form portion 153.

If a tab comprises a solid metal as shown in FIG. 3A, the coating can be performed by covering the solid metal tab with a strip of a heat sealable material and by applying heat to the portions of the tab and the strip which contact each other. To hermetically seal the coating strip to the tab, it is preferable to take a preliminary step by making the surface of a portion of the solid metal tab rough or uneven. The roughening increases the adhesion of the sealable material to the solid metal surface and makes the coating easier. It is sufficient for the rough surface to have the protrusions or depressions of at least 10 microns in height from a reference surface plane to have enough adhesion to make the sealing possible.

Fig. 5A depicts a top view of a portion of a solid tab that has an uneven, rough surface in the form of protrusions or depressions from a reference surface

plane in a repeated pattern. A cross-sectional view of a portion of the solid tab along the line 5B-5B in FIG. 5A is shown in FIG 5B. As shown in FIGs. 5A and 5B, the uneven surface of tab 160 has protrusions 162 thereon that protrude from surface 164 of the tab by distances preferably in the range of more than about 10 microns where the surface 164 defines a reference plane representing the surface of tab 160. Alternatively, tab 160 may be viewed as having a surface 162c with depressions 164 therein where the depressions have depths preferably more than about 10 microns from surface 162c that defines a reference plane. Thus, when the portion 160 of the solid metal tab having protrusions or depressions is sealed to a strip of the sealable material, the adhesion of the tab with the strip is increased. While in Figs. 5A and 5B, the uneven surface of the portion 160 of tab are shown to have a regular pattern of parallelograms, it will be understood that the pattern of the surface need not be regular. As long as the uneven surface of the tab portion is sufficient to develop adhesive properties that allows sealing the tab to the strip of the sealable material, the above-described advantages will be present and such variations are intended to be within the scope of the present invention.

The uneven surface described above may be made by a number of methods. It can be formed as part of the process for making the tab, such as when the tab is made by a molding process where the mold pieces can have surfaces that are mirror images of such uneven tab surfaces. It can be also made by an imprint process on a smooth surface, or by running a piece of smooth metal under a pressure wheel or between two gears. In addition, sand paper can be also used to make the solid metal surface rough resulting in a more or less randomly uneven surface.

After strip 114 has been formed on a portion of the tab 112, as shown in Figs. 3B, 3C, the strip 114 is then aligned with edge 28a as shown in Fig. 4A to hermetically seal end 112a and cell 26 within envelope 28, as described above. The adhesion between the edge 28a of envelope 28 and the strip 114 of the sealable material can be improved by shaping strip 114 so that it has a smooth curvature. filing or grinding down the edges of the strip of sealable material to make a smooth curvature. FIG. 6 is a cross-sectional view of the tab 112 and the strip 114 of heat-sealable material with the gradual curvature taken along the line 6-6 in FIG. 3A and along the line 6-6 in Fig. 4A. In addition, Fig. 6 also shows the positions of the upper and lower edges 28a', 28a" relative to strip 114 and tab 112 of Fig. 4A. As shown in FIG. 6, the strip of a sealable material 114 with the gradual curvature, such as at 114a, is attached to a center portion of solid tab 112. The gradual curvature (instead of abrupt corners) of strip 114 enables a better adhesion and sealing between the strip of the heat sealable material 114 with the edges 28a' and 28a".

The process of attaching a strip 114 of a sealable material to edges 28a of a protective package is substantially the same irrespective of whether the strip coats a solid metal tab, or coats and/or impregnates a mesh or an expanded metal tab. The mesh tab may comprise a woven fabric comprising metal coated nylon fibers.

The sealing of the heat-sealable material 114 to the protective package ("bag") 28 will now be described in more detail in reference to FIG. 4A. After the cell 26 is inserted into the opening 138 of the bag 28, the strip of heat sealable material 114 is aligned with the edges 28a of the bag 28 and then attached and sealed to the bag walls 28a', 28a" (Fig. 6) on the two

sides of the opening 138. The strip of material 114 may be the strip 114 of FIGs. 3A, 3B, or 153 of FIG. 4B and the tab may be the solid metal tab 112 of FIG. 3A or the metal mesh tab 112', 150 of FIGs. 3B, 4B. The sealing is performed by applying heat and pressure along arrows 140 (see FIG. 4A) to the strip of the heat-sealable material and to the walls of the bag on the both sides of the opening enclosing the strip. The heat and pressure are applied with the help of a heatsealer (not shown) which is a device well known in the art. The heatsealer comprises two heated jars (not shown) that come together along arrows 140 by air pressure. The battery is placed in between two jars. The heatsealer can develop temperatures within the range of 0° F to 300° F and pressures within the range of (0-500) Lb/in^2 which is sufficient for the purposes of heatsealing the sealable strip to the protective package. The heatsealer also seals and closes the opening 138 so that the cell is hermetically packed inside the protective package 28 with the metal tab passing through the package to serve as one of the terminals. More terminals can be made in the same manner. If the sealable material becomes liquid when heated, only application of heat is necessary in order to seal the sealable material to the protective package itself.

Usually the protective package 28 is made from plastic layer and aluminum foil. Ultrasonic welding is available for sealing such protective package 28 to the sealable material unless the package material is very thick.

The invention has been described above by reference to various embodiments. It will be understood that different changes and modifications may be made without departing from the scope of the invention which is to be limited only by the appended claims.

WHAT IS CLAIMED IS:

1. An electrical battery comprising:

at least one electrical cell, said cell including at least one terminal; and

a protective package layer surrounding said at least one cell, said layer sealingly connected to said terminal;

wherein said terminal includes a portion having an uneven surface with protrusions or depressions of at least 10 microns in height from a reference surface plane;

and wherein said protective package layer is sealingly connected to said terminal at said portion having an uneven surface to achieve a better seal.

2. The battery of claim 1, wherein said layer hermetically seals the at least one cell and to its terminal.

3. The battery of claim 1, wherein said uneven surface has a repeated pattern of said protrusions or depressions.

4. The battery of claim 1, further comprising a sealable material hermetically sealed between the portion of the terminal and the protective layer, said material being different from but compatible with material of the protective package layer.

5. The battery of claim 4, wherein said sealable material is in the shape of an elongated strip having a cross-section with gradual curvature.

6. The battery of claim 1, wherein said terminal comprises a mesh.

7. The battery of claim 1, wherein said terminal comprises an expanded metal.

8. An electrical battery comprising:

at least one electrical cell, said cell including at least one terminal; and

a protective package layer surrounding said at least one cell, said layer sealingly connected to said terminal, said terminal having a thickness greater than about 2 mils and said protective package layer having a thickness of about 7 mils or less.

9. The battery of claim 8, said terminal having a thickness greater than about 7 mils.

10. The battery of claim 9, wherein said terminal includes a portion with an uneven surface having protrusions or depressions of at least 10 microns in height from a reference surface plane;

and wherein said protective package layer is sealingly connected to the uneven surface of said portion of the terminal to achieve a better seal.

11. The battery of claim 10, further comprising a sealable material hermetically sealed between the portion of the terminal and the protective layer, said material being different from but compatible with material of the protective package layer.

12. The battery of claim 11,

wherein said sealable material is in the shape of an elongated strip having a cross-section with gradual curvature.

13. The battery of claim 9, wherein said terminal comprises a mesh structure.

14. The battery of claim 9, wherein said terminal comprises an expanded metal.

15. A method of making an electrical battery comprising the steps of:

coating or impregnating at least a portion of a terminal with a sealable material;

enclosing an electrical cell with a protective layer;

sealing said sealable material on or in said terminal to said protective layer.

16. The method of claim 15, wherein said coating or impregnating step is performed by using a sealable material different from but compatible with material of the protective layer.

17. The method of claim 15, said terminal comprising a mesh structure or an expanded metal, wherein the step of coating or impregnating said portion of said terminal with said sealable material includes impregnating said structure or expended metal with said sealable material.

18. The method of claim 17, wherein the step of impregnating includes dipping said terminal into a solution of plastic.

19. The method of claim 15, said portion of protective layer enclosing the terminal, the coating or impregnating step covering said terminal with a layer of said sealable material, and wherein the sealing step

includes heating the sealable material and the portion of said protective layer.

20. The method of claim 19 further comprising the step of applying pressure to said portion of said terminal and the layer of sealable material.

21. The method of claim 15, wherein the step of coating or impregnating said portion of said terminal with said sealable material includes molding a sealable material around said terminal.

22. The method of claim 15, wherein said coating or impregnating step coats the portion of the terminal with an elongated strip of sealable material having a cross-section with a gradual curvature.

23. The method of claim 22, said coating or impregnating step including forming said strip of sealable material, said method further including grinding or filing the strip so that the strip has a cross-section with a gradual curvature.

24. The method of claim 15, further comprising a step of providing a terminal having a portion with an uneven surface.

25. The method of claim 24, said providing step including making imprints on a surface of a terminal by running said surface of the terminal under a pressure wheel or between two gears, or by rubbing with sand paper.

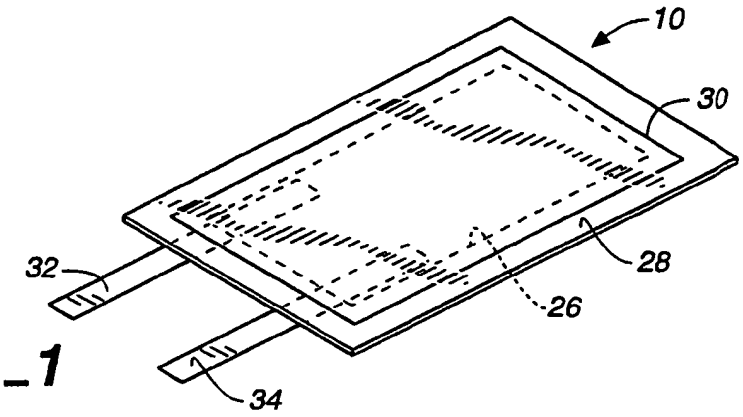

FIG._1

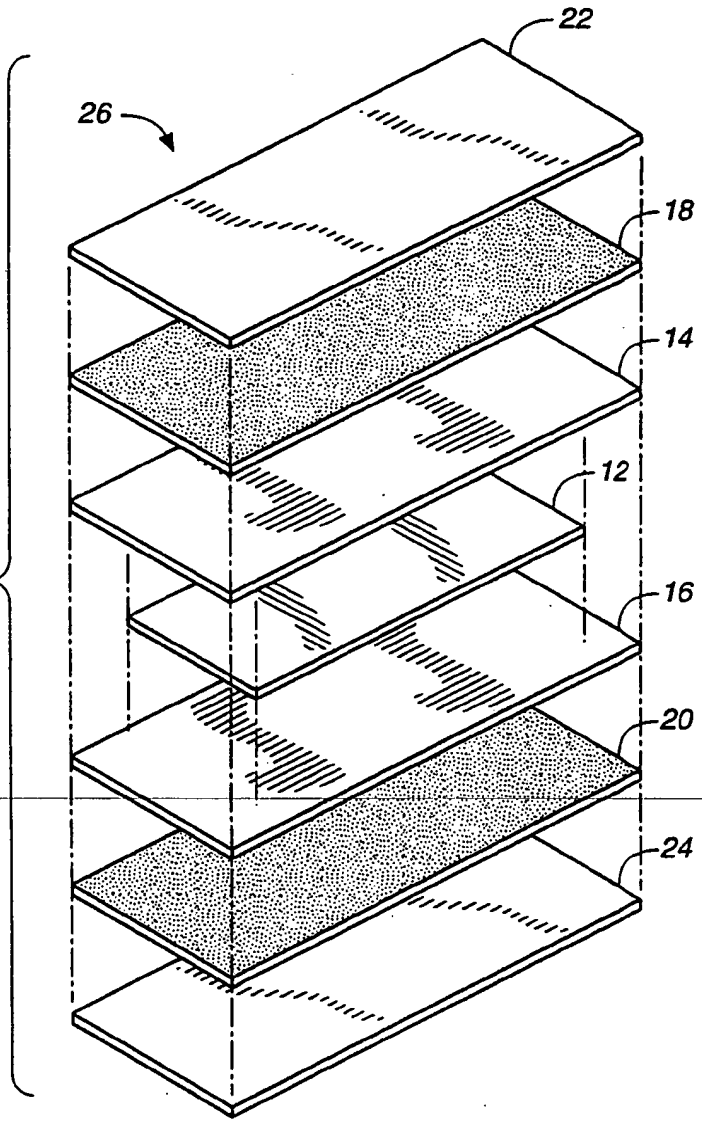

FIG._2

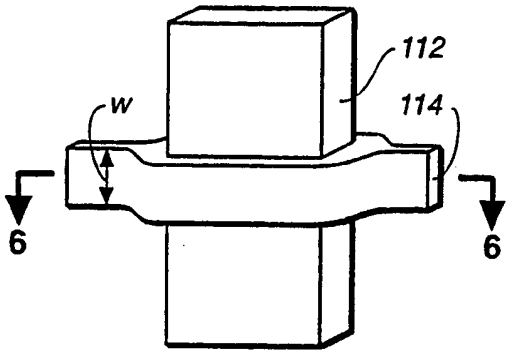

FIG._3A

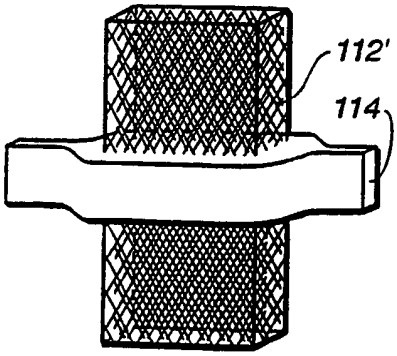

FIG._3B

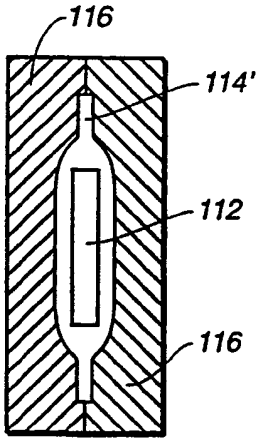

FIG._3C

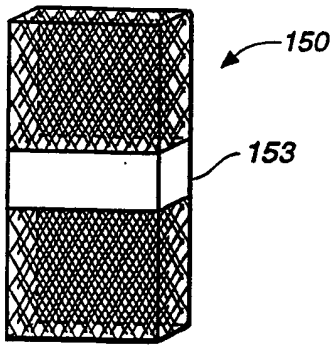

FIG._4B

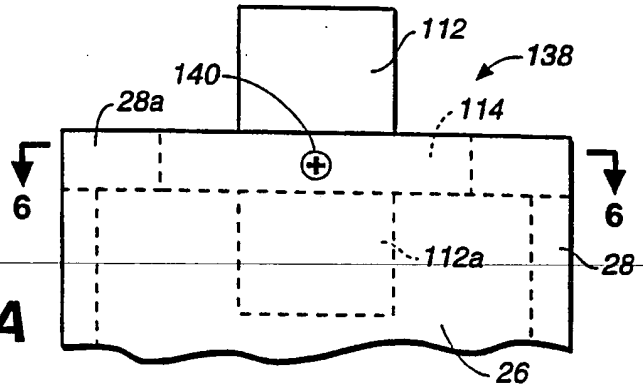

FIG._4A

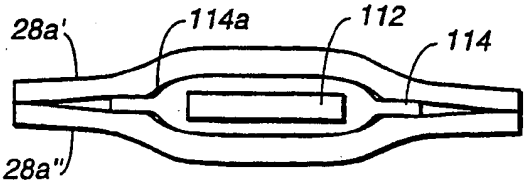

FIG._6

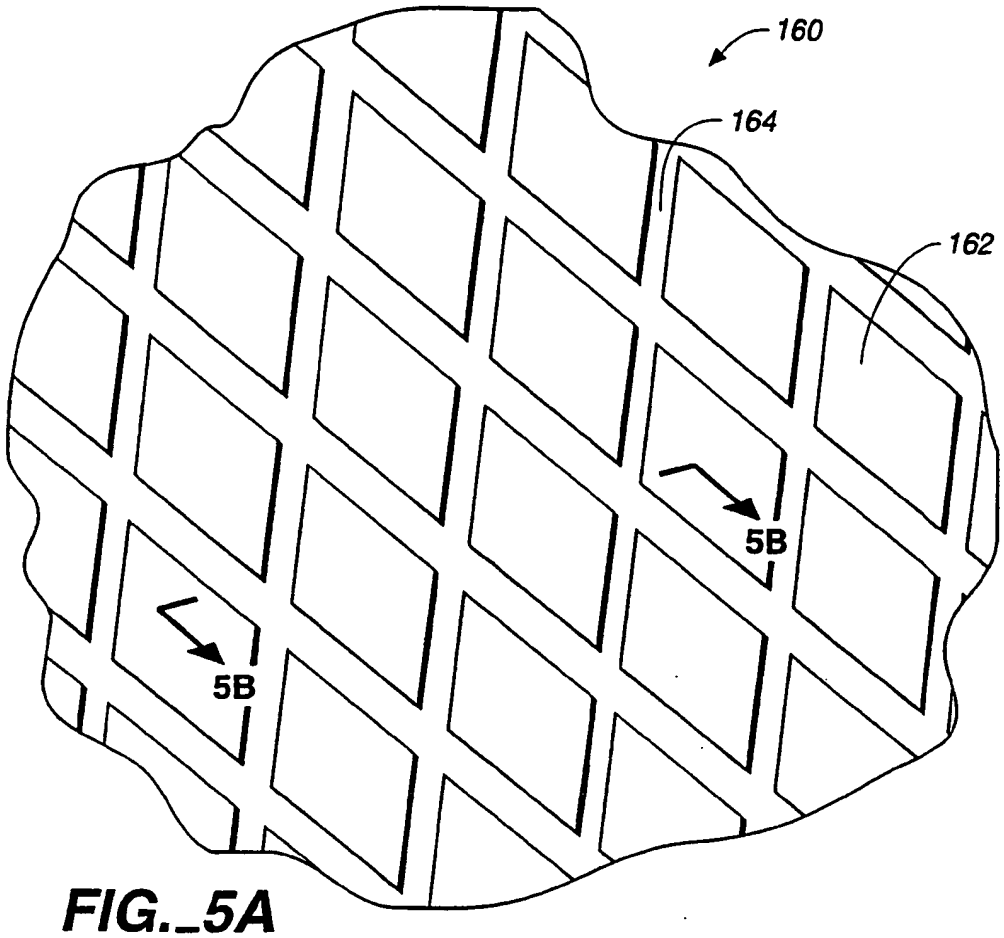

FIG._5A

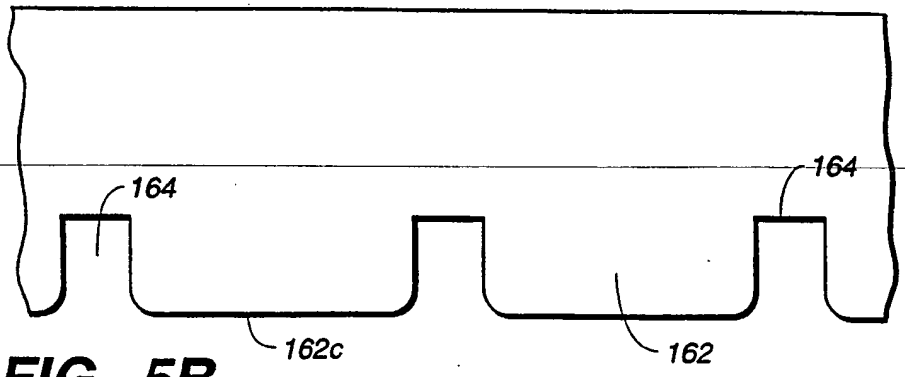

FIG._5B

INTERNATIONAL SEARCH REPORT

International application No.
PCT/US96/12441

A. CLASSIFICATION OF SUBJECT MATTER

IPC(6) :H01M 2/02, 4/04
US CL :429/211
According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)

U.S. : 429/211

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

429/211, 181-185, 178

Electronic data base consulted during the international search (name of data base and, where practicable, search terms used)

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
Y	A, US, 3,859,134 (SHIRODKER) 07 JANUARY 1975, SEE ENTIRE DOCUMENT.	1-25
Y	A, US, 4,092,464 (DEY ET AL) 30 MAY 1978 , SEE COL. 2, LINE 49- COL. 3, LINE 10;	1-14
Y	A, US, 4,664,994 (KOIKE ET AL) 12 MAY 1987, SEE ENTIRE DOCUMENT.	1-25

☐ Further documents are listed in the continuation of Box C. ☐ See patent family annex.

* Special categories of cited documents:

"A" document defining the general state of the art which is not considered to be of particular relevance

"E" earlier document published on or after the international filing date

"L" document which may throw doubts on priority claim(s) or which is cited to establish the publication date of another citation or other special reason (as specified)

"O" document referring to an oral disclosure, use, exhibition or other means

"P" document published prior to the international filing date but later than the priority date claimed

"T" later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention

"X" document of particular relevance; the claimed invention cannot be considered novel or cannot be considered to involve an inventive step when the document is taken alone

"Y" document of particular relevance; the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art

"&" document member of the same patent family

Date of the actual completion of the international search	Date of mailing of the international search report
12 SEPTEMBER 1996	07 JAN 1997
Name and mailing address of the ISA/US Commissioner of Patents and Trademarks Box PCT Washington, D.C. 20231 Facsimile No. (703) 305-3230	Authorized officer for ANTHONY SKAPARS Telephone No. (703) 308-2773

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